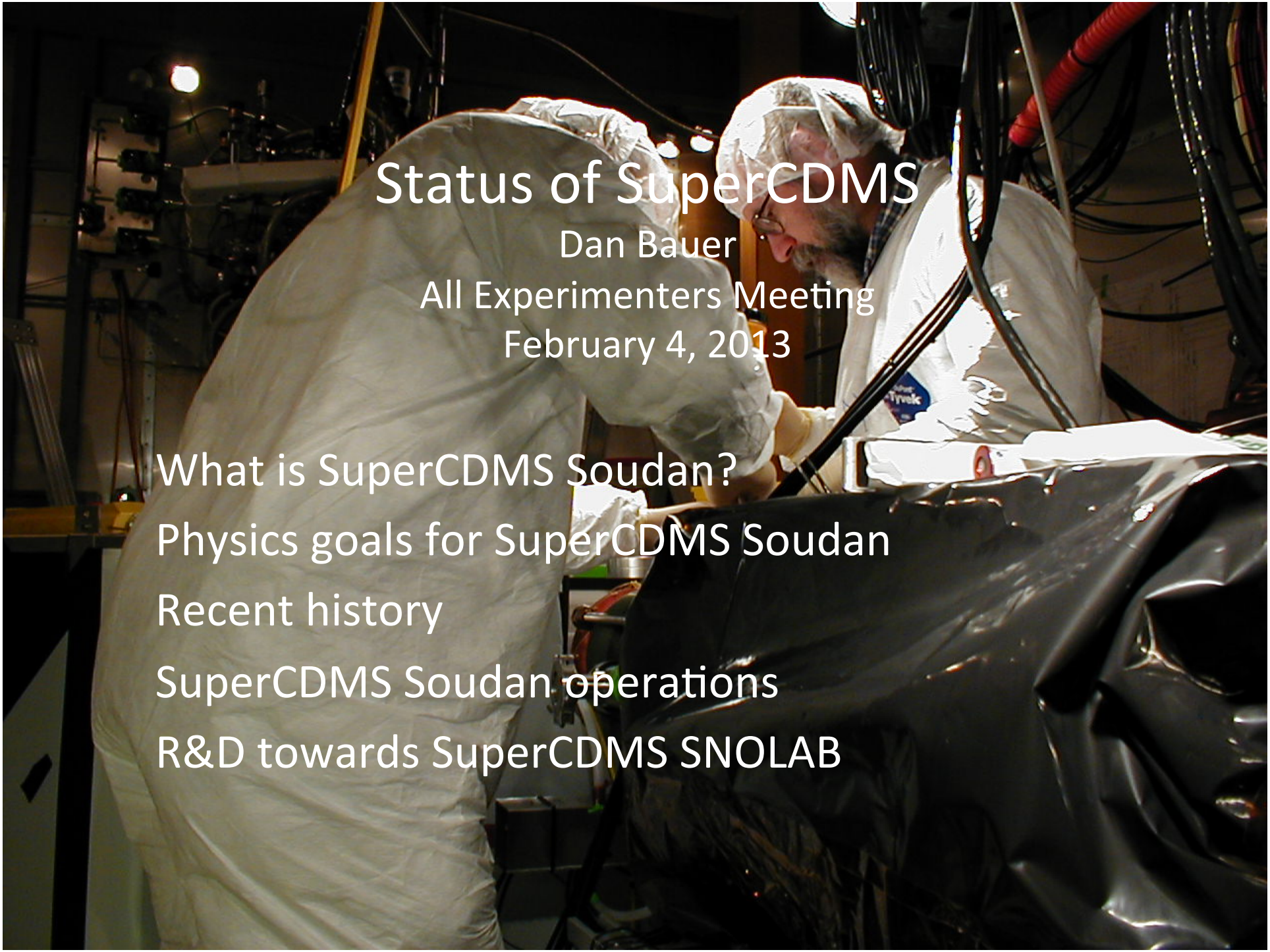


Status of SuperCDMS

Dan Bauer

All Experimenters Meeting

February 4, 2013

- What is SuperCDMS Soudan?
- Physics goals for SuperCDMS Soudan
- Recent history
- SuperCDMS Soudan operations
- R&D towards SuperCDMS SNOLAB

SuperCDMS Soudan Experiment Design

Detectors

Pure germanium crystals with interleaved charge and phonon sensors on both sides to provide excellent background rejection

Cryogenics

Cool to near absolute zero in order to see single particle interactions

Shielding and Veto

Reduce flux of radioactive decay particles near the detectors

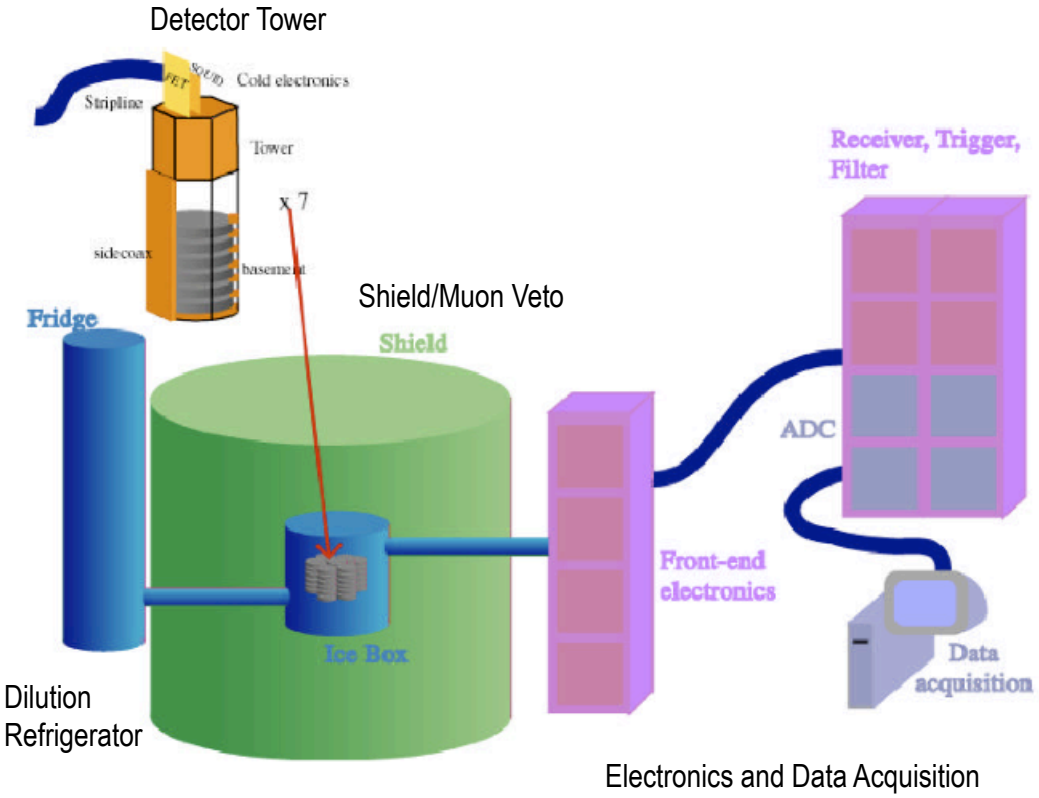
Actively tag any interactions associated with cosmic rays

Electronics and Data Acquisition

Custom cold and warm electronics with commercial readout electronics and trigger

DAQ software with custom fast event builder and Java-based run control and monitoring

Uses the existing CDMS II Infrastructure but with new detectors



Goals for SuperCDMS Soudan

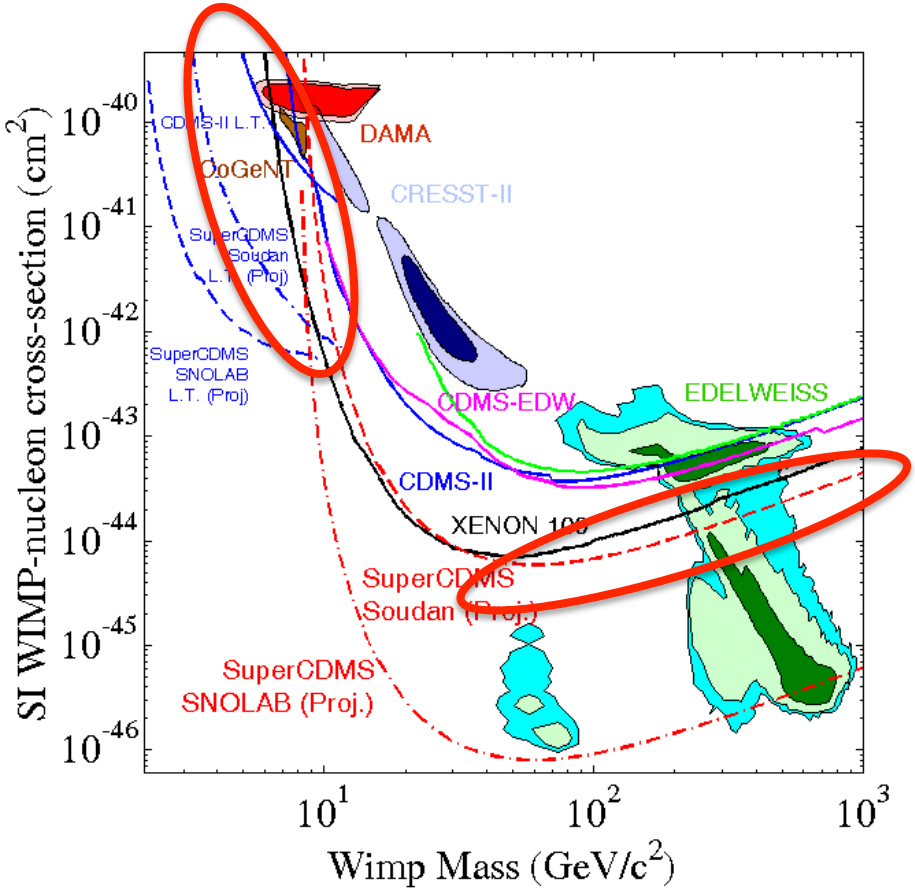
We now have a new detector technology (iZIP) that will provide control of backgrounds for the foreseeable future.

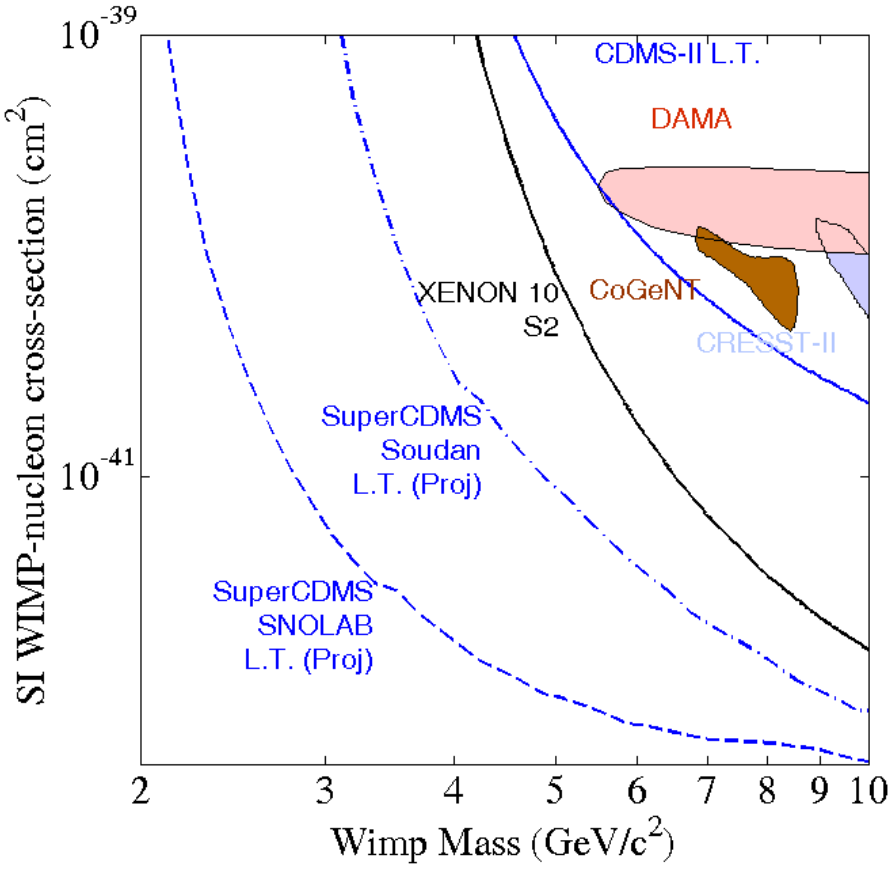
The SuperCDMS Soudan experiment is already operating with 9 kg of Ge detectors using this new technology and has initial results which promise background-free WIMP sensitivity for three years of operation.

The experiment is competitive with, and complementary to, other G1 experiments and will also validate the designs for a second generation SuperCDMS SNOLAB experiment.

SuperCDMS Soudan Physics Reach

Best sensitivity for low (<10 GeV) and high (> 1 TeV) mass WIMPS





Requirements to meet science goals

Stable data taking for at least 3 years is the requirement for achieving high-mass (>100 GeV) WIMP sensitivity and studying annual modulation. Would need to run until March 2015.

Much shorter exposures (<200 kg-days) are needed to achieve world leading sensitivity to low-mass (<10 GeV) WIMPS. Will have sufficient exposure by fall 2013.

Already have enough data to demonstrate that iZIP detectors provide excellent surface background rejection.

Recent History of SuperCDMS Soudan

Event	Date
Soudan shaft fire	Mar 17, 2011
Install iZIP detectors	Oct 25, 2011
Cool to 50 mK	Nov 29, 2011
Start of operations	Mar 1, 2012
Stable data taking	Apr 9, 2012
Data set with very low energy threshold	Aug/Sep 2012
One year continuously at 50 mK!	Nov 29, 2012
Reliquefiers operational	Jan 21, 2013

Aftermath of the shaft fire

All better three months later

New larger underground diesel generator backs up the entire CDMS experiment

What's an iZIP?

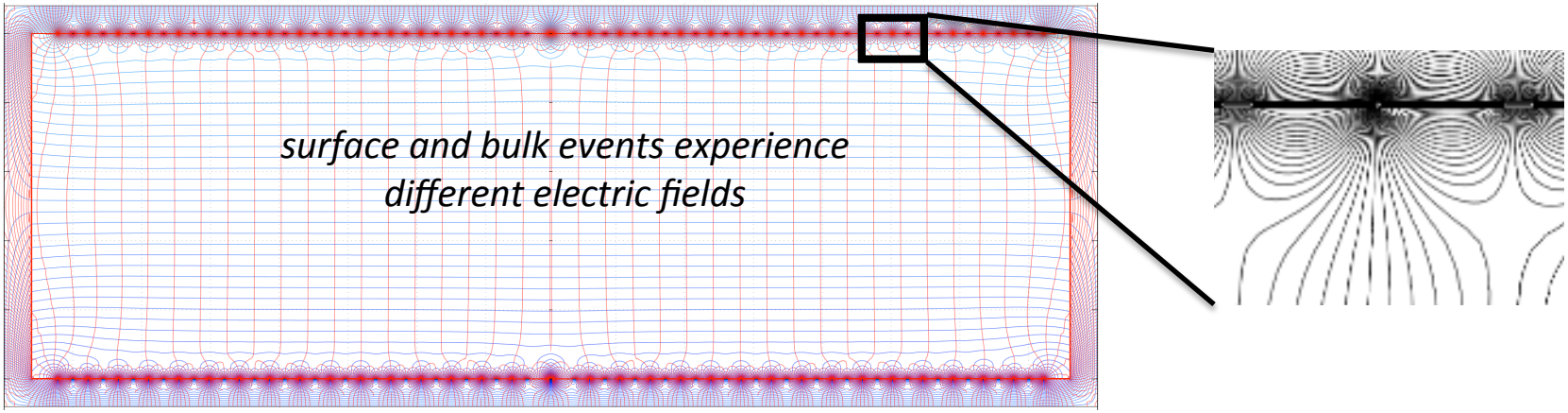
(no, it's not made by Apple)

Measure both phonons and ionization for each particle interaction; ratio used to identify nuclear recoils

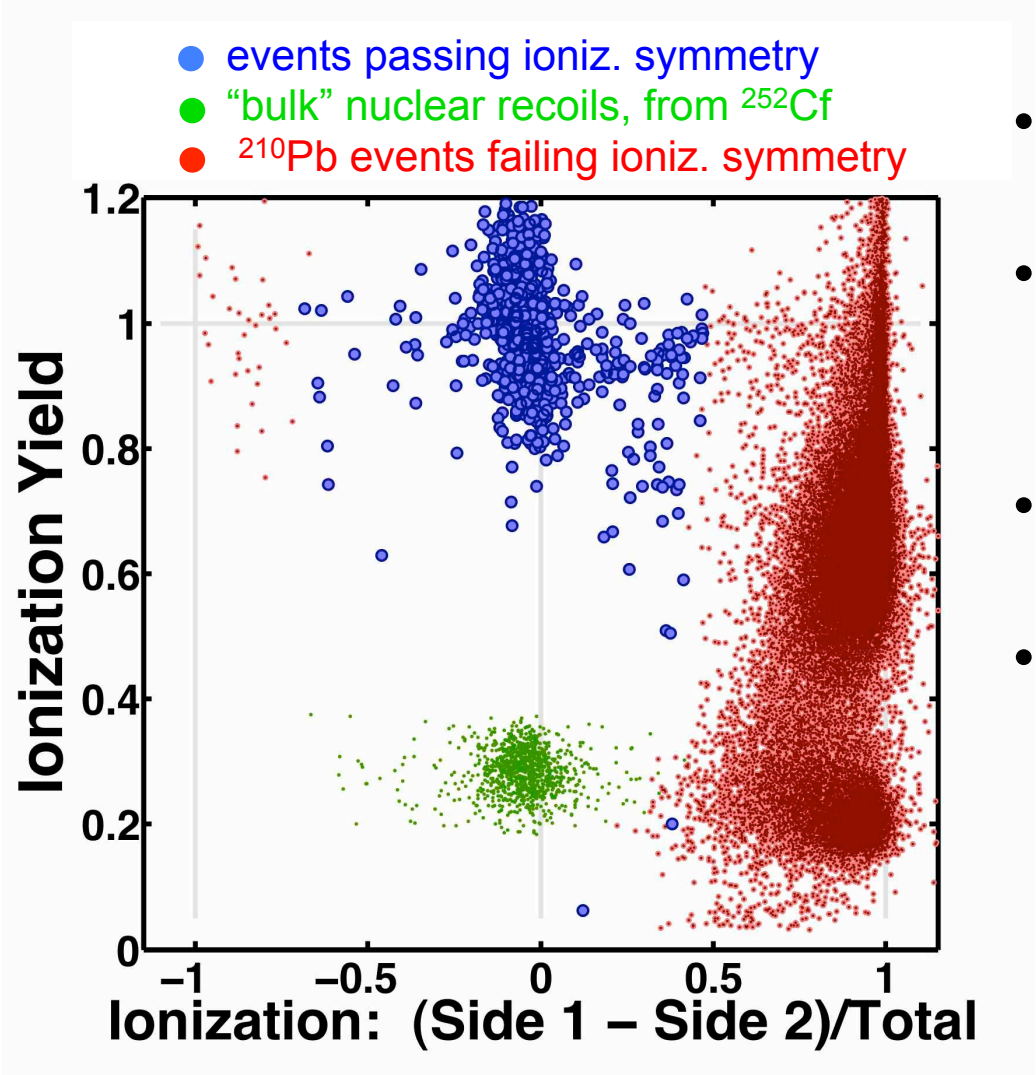
Interleaved phonon and charge sensors on both sides of the Ge crystal

Charge asymmetry between surfaces used to reject surface events (x100 better than in CDMS II!)

Phonon asymmetry and timing provides additional discrimination against electron recoils



Ionization surface event discrimination



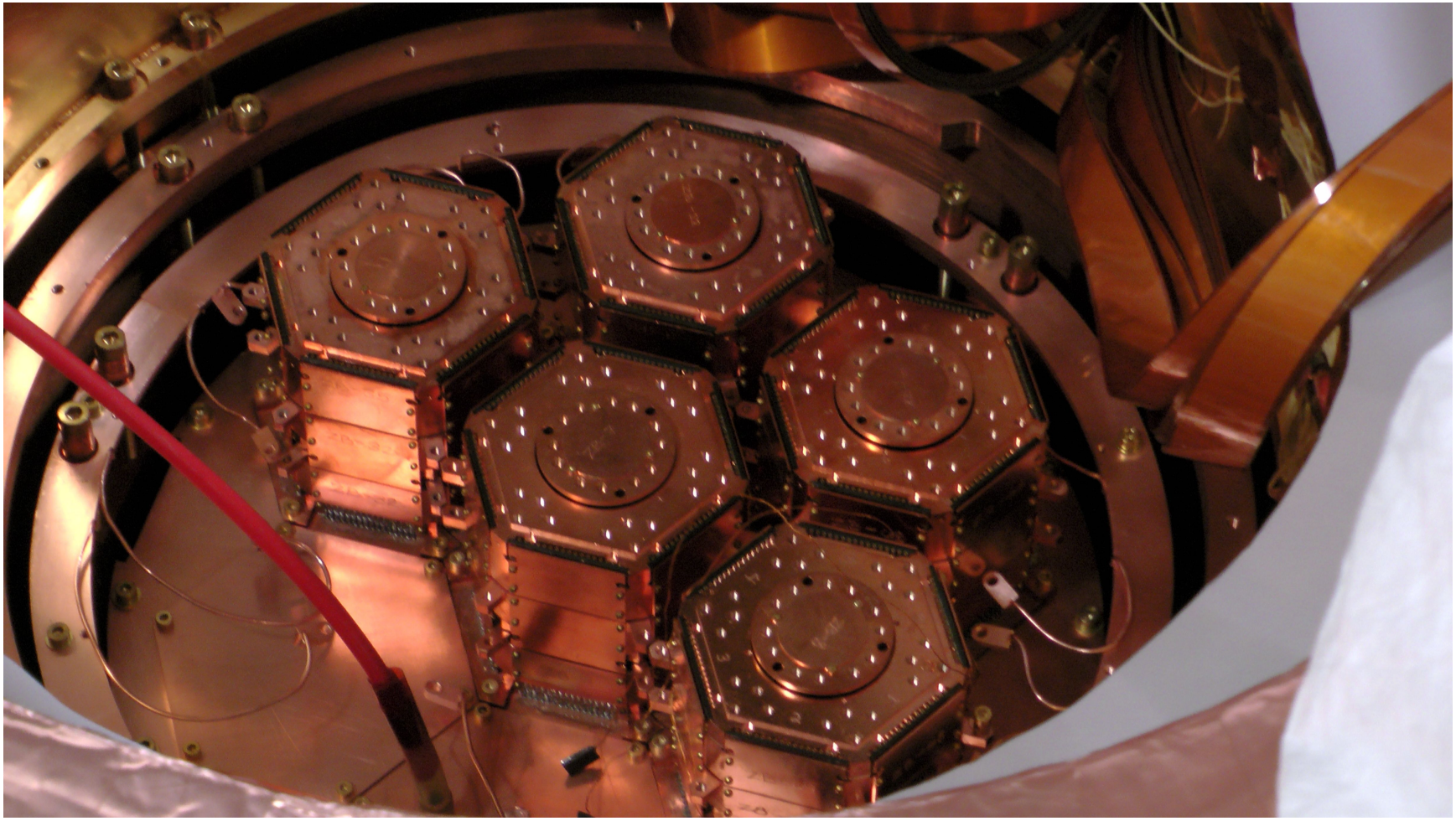
- ~80,000 surface events analyzed
- 0 events in signal region after ionization symmetry & yield selection
- 60% efficiency (~50% better than CDMSII)
- *phonon discrimination not exploited in this analysis*

> 10X what's needed for 9 kg SuperCDMS !

Analyzed region [8, 100] keV$_{nr}$

iZIP Detector Installation

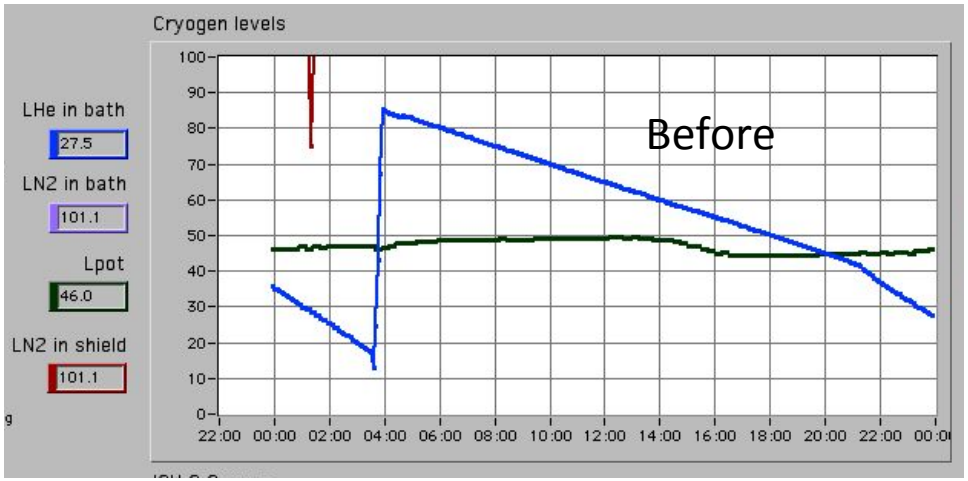
15 Ge detectors, each 0.6 kg, arranged in 5 towers

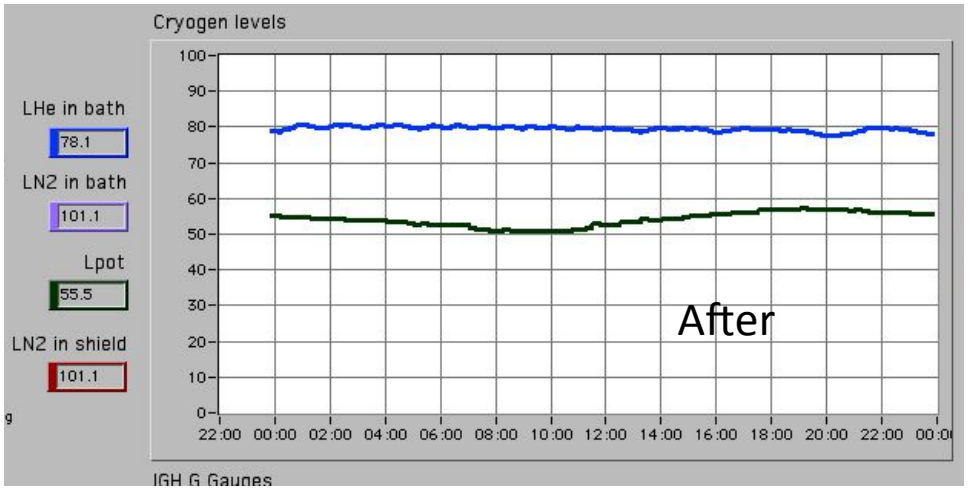


Reliquefier retrofit

- CDMS uses a dilution refrigerator for cooling
  - Requires daily transfers of LHe and LN
  - Very expensive (~$250K/year) and time consuming
    - 1.5 hours/day with no data, or about 16% of livetime
- Retrofitted a reliquefier system at Soudan
  - Based on 3 Cryomech two-stage LHe reliquefiers and 1 single stage LN reliquefier
  - Very limited space to fit this in; requires low-loss transfer line to return cryogens to dilution fridge
  - Rich Schmitt designed this and commissioned with Mark Ruschman and Soudan technical staff
  - It is now working and saves ~$600/day, and livetime!

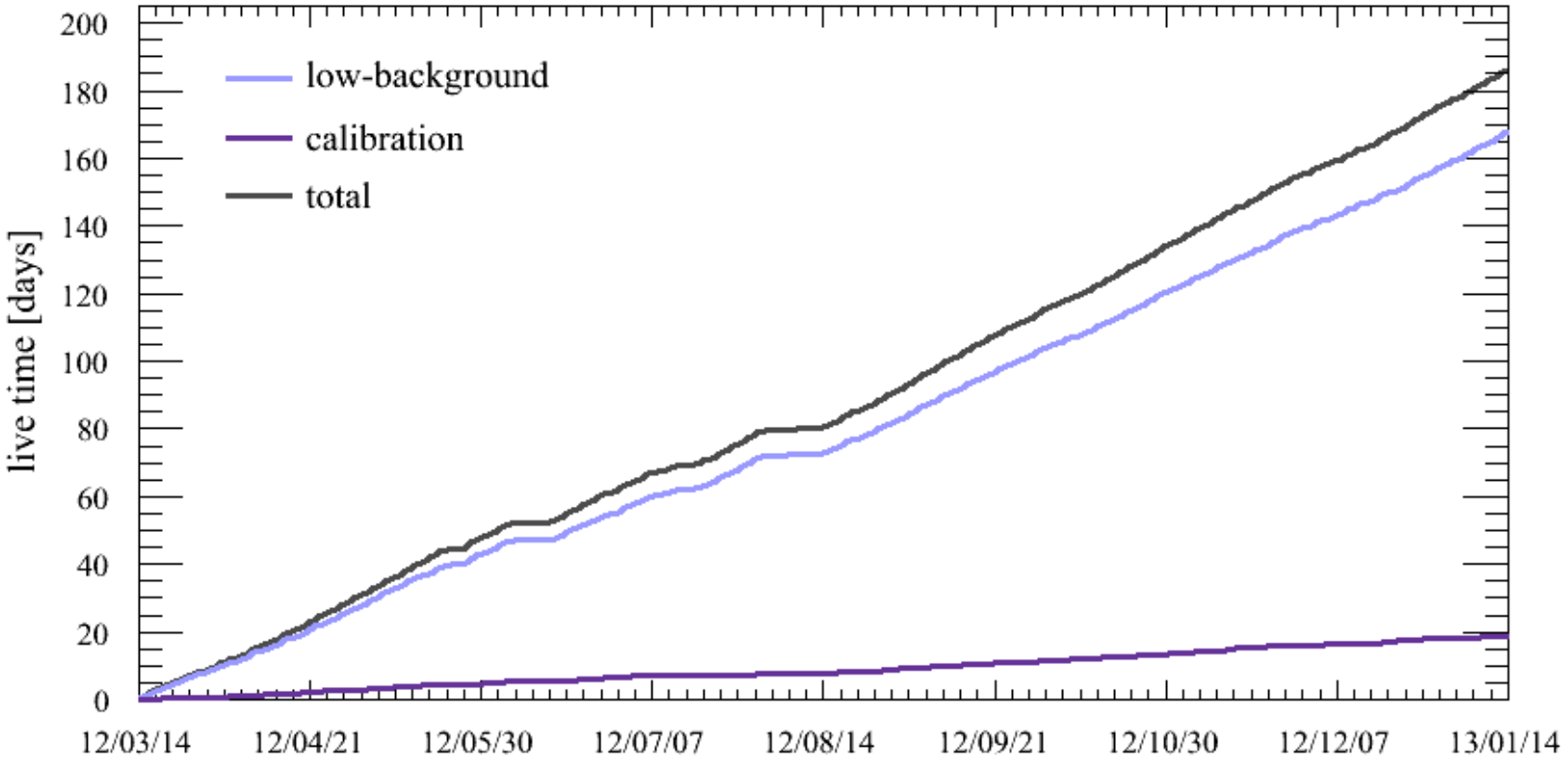
Reliquefiers





SuperCDMS Soudan Status

- Mostly stable running
  - 10% of livetime used for in-situ gamma calibration with 133 Ba
  - Neutron calibration every few months with 252Cf source
  - Occasional interruptions for maintenance, low threshold studies, ….



SuperCDMS Soudan Operations Issues

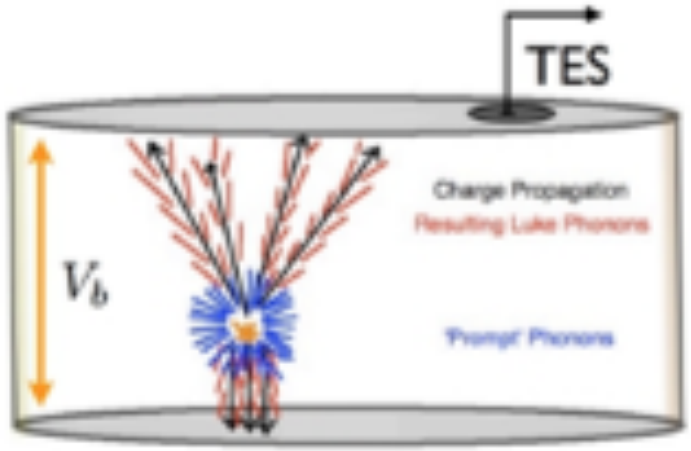
- Soudan infrastructure Issues
  - Relying on aging power feed in shaft
    - Working on better measurements of power usage
  - Air handlers causing vibrations
    - Replace motors with two-speed versions
  - Networking is outdated
    - Keep patching it up but needs new equipment
  - Cryogenics and electronics are 15 years old
    - Upgrading parts that fail and vigilant maintenance

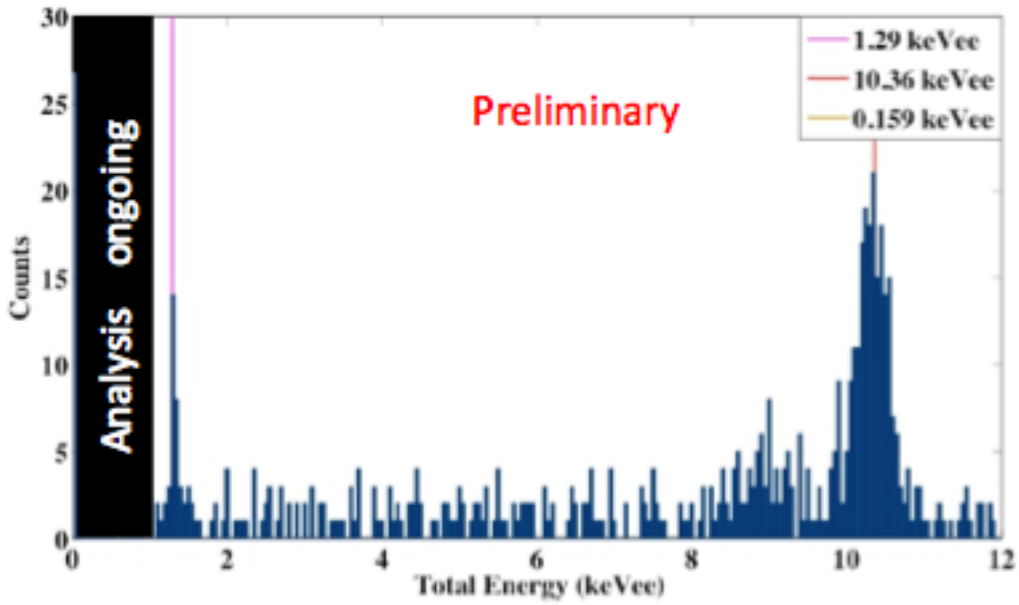
SuperCDMS Soudan Operations Issues

- Detector Issues
  - Failed channels
    - Several detectors have bad channels (cold shorts)
    - Source is believed to stem from quality control issues
    - Redundancy of charge/phonon channels means we can work around these issues in analysis
  - Low frequency noise
    - Combination of vibration sensitivity and 60 Hz harmonics
    - Have achieved 2 keV thresholds on enough detectors to do low threshold WIMP search
    - Super-low (<150 eV) threshold on one detector biased in a special manner (CDMSlite)

Low-mass WIMP search with SuperCDMS Soudan

- Data set from one detector in CDMSlite mode
  - Analysis ongoing; results by spring





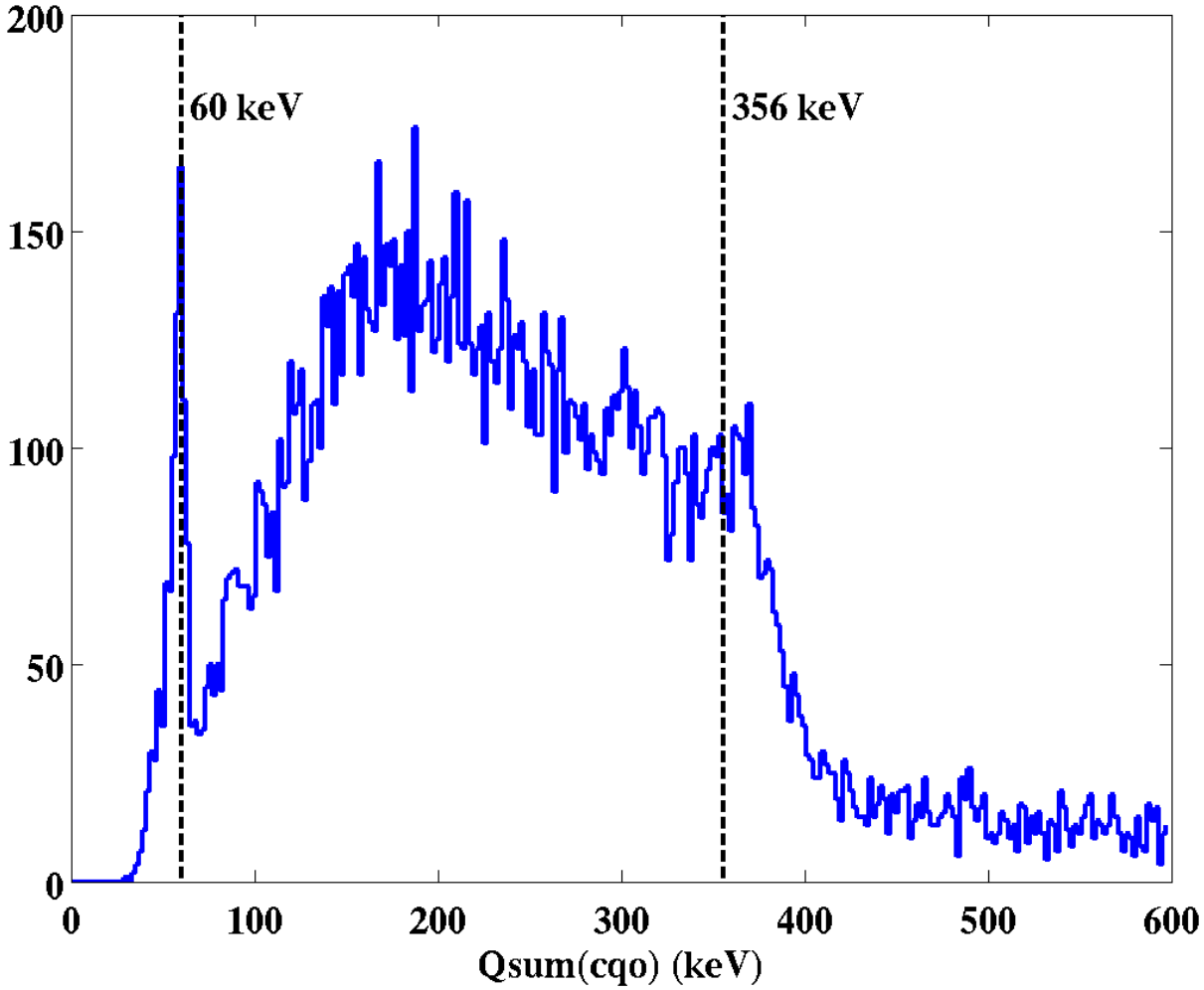
The next stage: SuperCDMS SNOLAB?

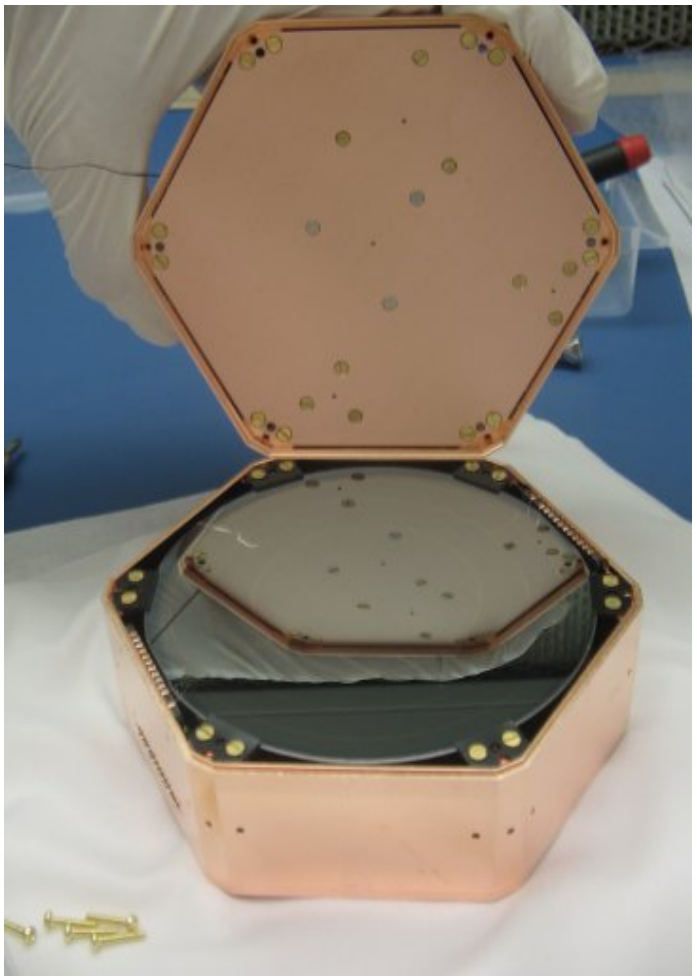
- A next-generation (G2) experiment designed for < 0.5 event background WIMP-nucleon cross section sensitivity x10 better than Soudan
- Essential parameters:
  - 200 kg Ge target mass (150 kg fiducial)
  - Cryogenics system designed for up to 400 kg of detectors at <40 mK
  - Active and passive shielding to achieve < 1 event background in 4 years of operation
  - Location at 6000 mwe SNOLAB ladder lab

SuperCDMS SNOLAB R&D

- Currently doing R&D towards conceptual design
  - Have developed larger (1.2 kg) iZIPs
  - Streamlining detector fab and testing
  - Developing more robust towers and reduced heat load electronics (FETs -> HEMTs)
  - Modern DAQ and single-card warm electronics in place of 9U/6U chain
  - New cryogenics design to reach lower temps
  - Cleaner passive shielding and active neutron veto to reduce backgrounds
  - Automated calibration system

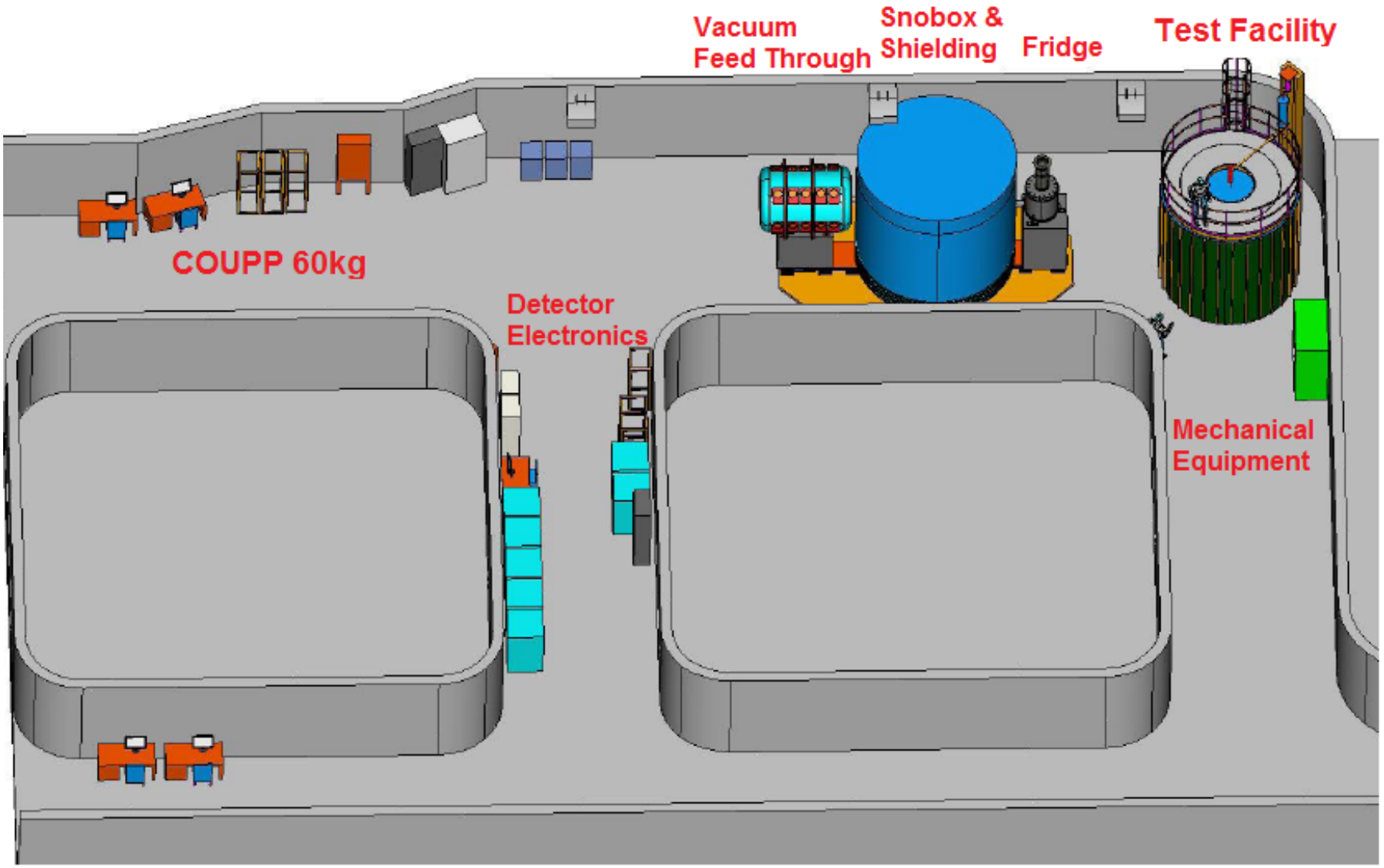
100 mm iZIP performance





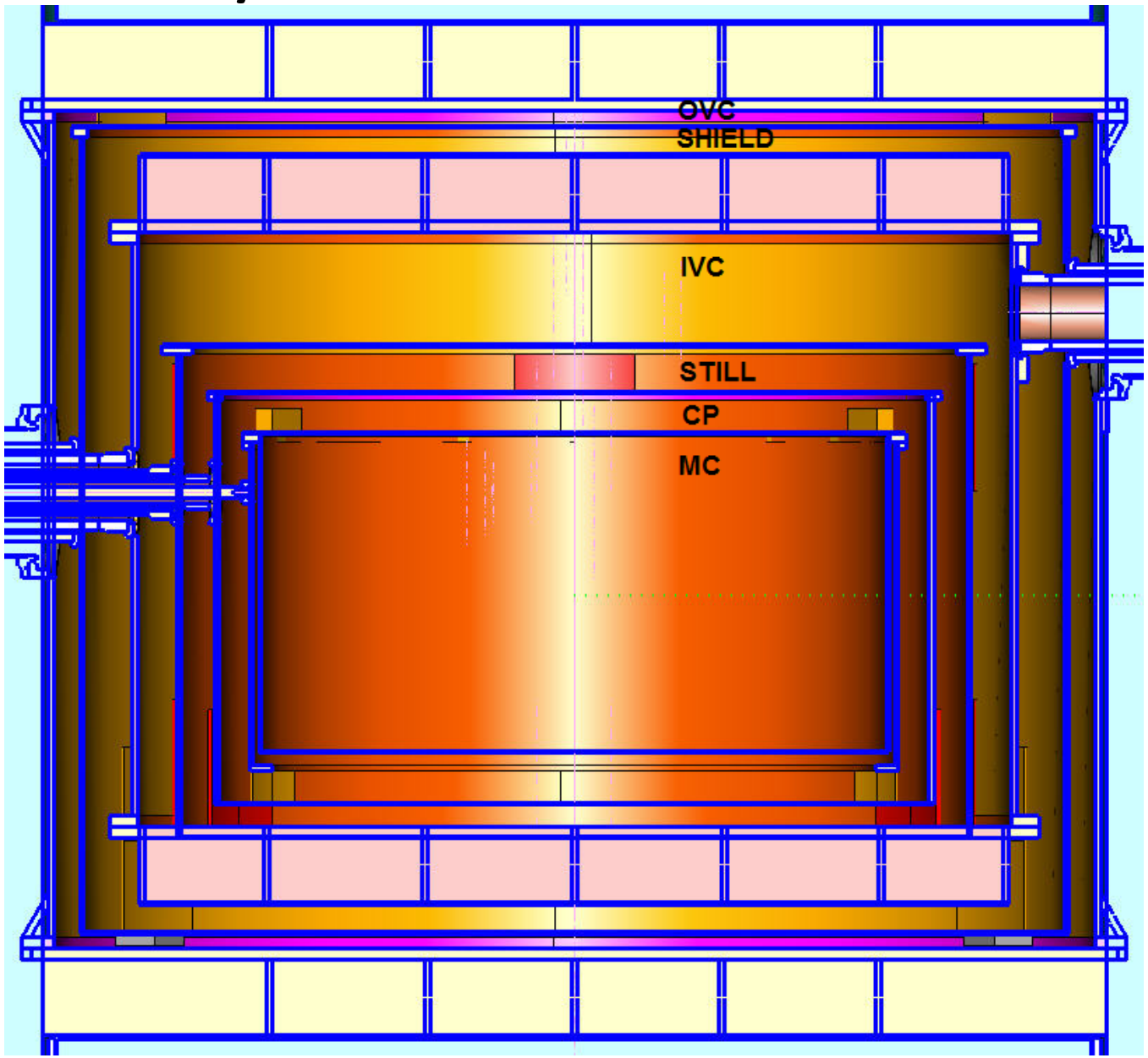
From Paul Brink, TIPP 2011

General Layout

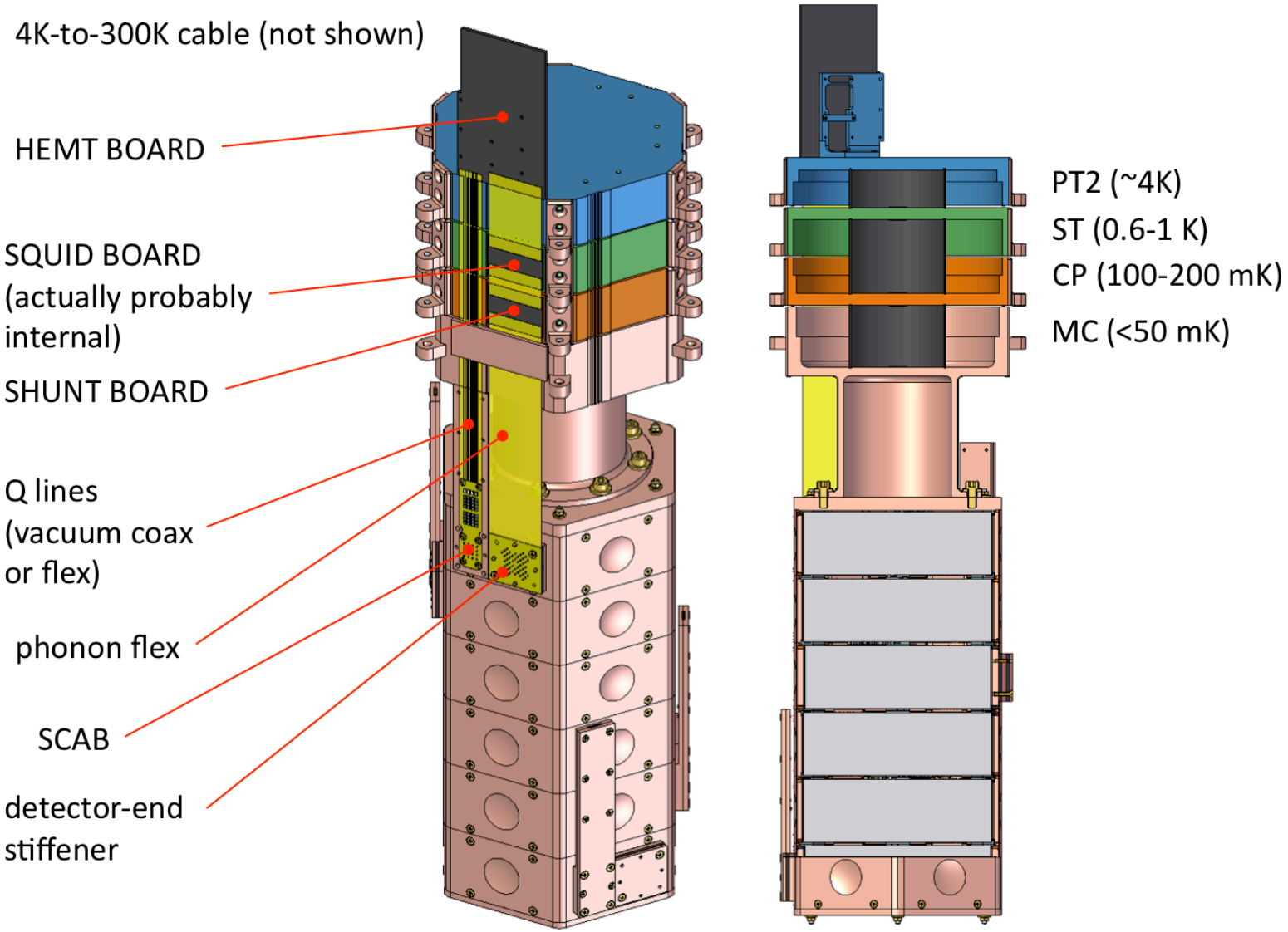


Snobox w/removable MC

- MC
  - 47 inch ID
  - 21 inch high
- OVC
  - 69 inch OD
  - 49 inch high



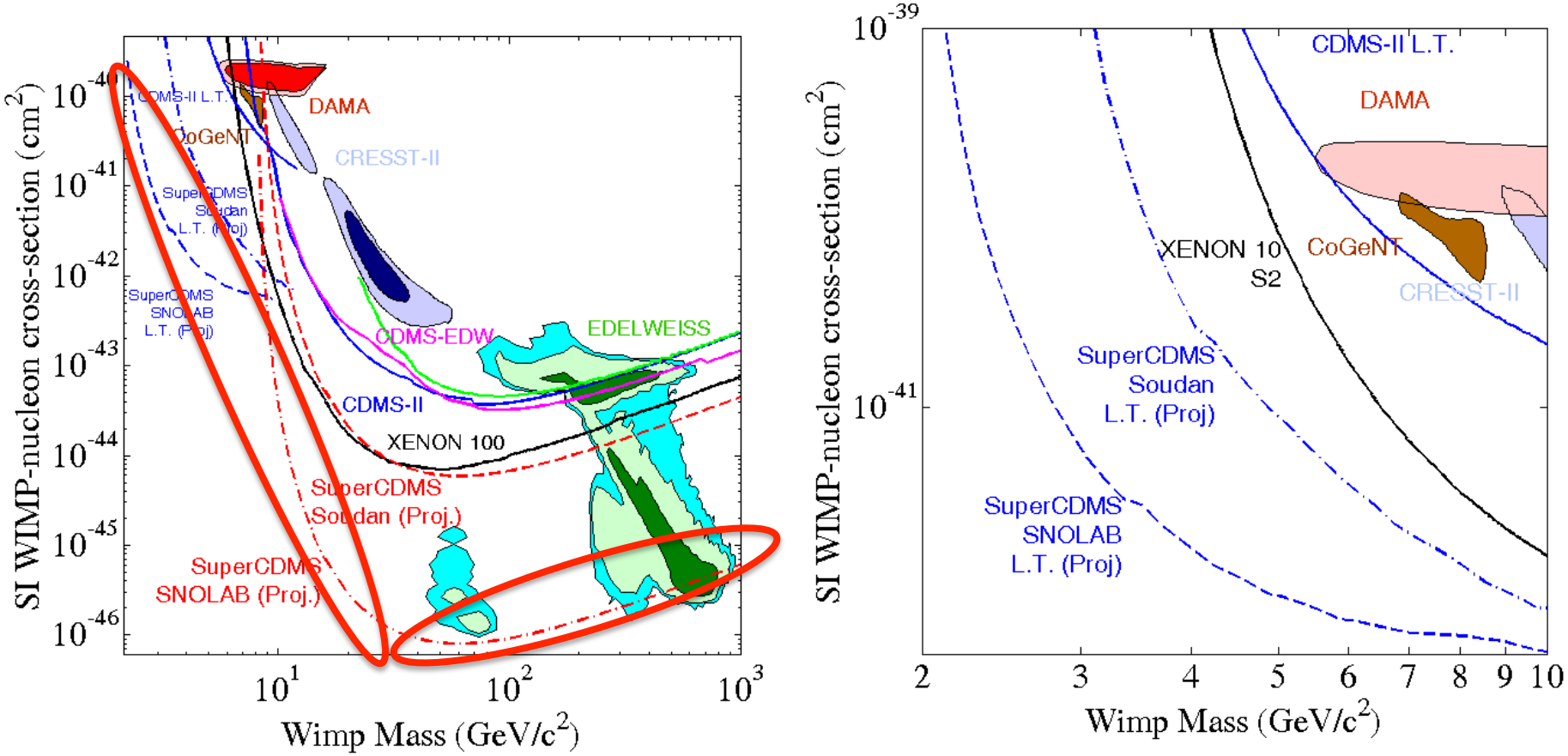
Redesigned tower structure



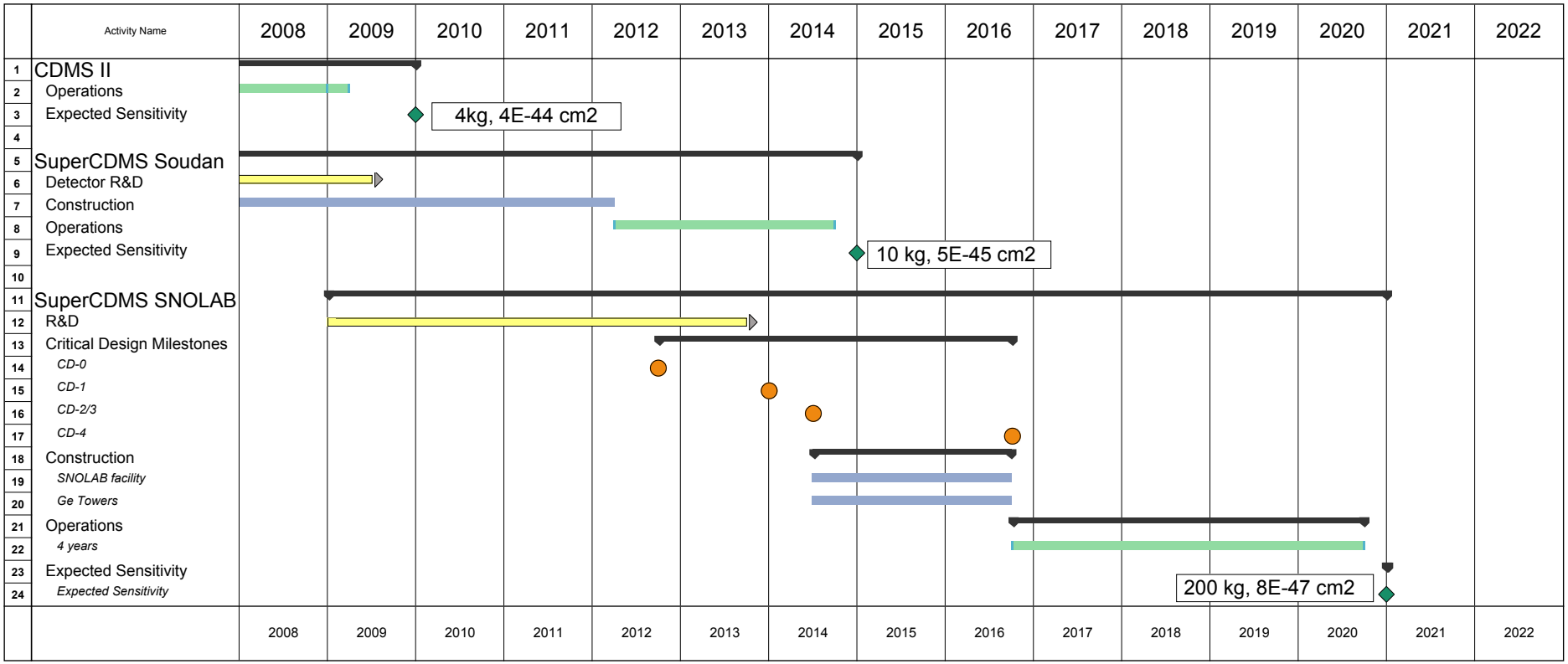
drawings courtesy of Marco Oriunno/SLAC

SuperCDMS SNOLAB Physics Reach

Sensitivity comparable to other proposed G2 experiments



SuperCDMS Experiment Schedule



Summary

- SuperCDMS Soudan is operating well
  - iZIPs demonstrate excellent control of backgrounds
  - Low (high) mass WIMP results by 2013 (2015)
- SuperCDMS SNOLAB in full R&D
  - Expect MIE project to start in 2014
  - Construction finished in 2016/2017
  - We hope this might be the discovery generation of dark matter direct detection experiments!